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DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
SPECIFICATION

AIR ROUTE SURVEILLANCE RADAR (ARSR-3) ANTENNA RADOME

1. SCOPE

1.1 Scope. - This specification sets forth the technical requirements for the design and fabrication of a standard radome for Air Route Surveillance Radar (ARSR-3) facilities. This specification is to be used with Specification FAA-E-2483b Air Route Surveillance Radar (ARSR-3).

2. APPLICABLE DOCUMENTS

2.1 FAA documents.- The following FAA standards, drawings, and specifications, of the issues specified in the invitation for bids or request for proposals, form a part of this specification and are applicable in their entirety unless otherwise specified herein.

2.1.1 FAA standards

FAA-STD-002	Federal Aviation Agency Standard for Engineering Drawings
FAA-STD-005b	Preparation of Specification Documents
FAA-STD-013a	Quality Control Program Requirements
FAA-STD-2100	Electronic Equipment, General Requirements
AC 70/7460-1C	Obstruction Marking and Lighting

2.1.2 FAA specifications

FAA-E-2483b	Air Route Surveillance Radar (ARSR-3)
FAA-E-2483b Supplement 3	Integrated Beacon Feed System (ARSR-3)
FAA-C-2498	Air Route Surveillance Radar (ARSR-3) Antenna Tower
FAA-E-2496a	Establishment of Air Route Surveillance Radar (ARSR) System
FAA-D-2494	Parts 1 and 2 Instruction Book Manuscripts Technical: Equipment and Systems, Requirements

2.2 Federal standards

FED-STD-595	Colors

Department of Labor, Title 29, Chapter XVII, Part 1910, Occupational Safety and Health Standards

2.3 Other publications

2.3.1 Uniform Building Code, Volume I, Current Edition

2.3.2 ASTM standards

2.3.3 Lightning Protection Code - Publication No. 78

(Copies of this specification and other FAA specifications, standards, and drawings may be obtained from the Contracting Officer in the Federal Administration Office issuing the invitation for bids or request for proposals. Request should fully identify material described, i.e., specification, standard, amendment, and drawings, numbers and dates. Request should cite the invitation for bids, request for proposals, or the contract involved, or other use to be made of the requested material.)

(Copies of the Uniform Building Code may be requested from International Conference or Building Officials, 50 South Robles, Pasadena, California 91101).

(Copies of ASTM Standards may be requested from American Society of Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103).

(Copies of the Lightning Protection Code may be requested from National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts 02110).

3. REQUIREMENTS

3.1 Items to be furnished by the contractor

3.1.1 Equipment.- The contractor shall furnish an antenna radome, complete, in accordance with all specification requirements. The quantity of radomes to be furnished will be specified in the contract schedule.

3.1.2 Data and documentation.- Documentation for the radome shall be prepared and furnished by the contractor, complete, in accordance with all specification requirements and shall include the items tabulated below.

(a) Calculations--including stress analysis, resultant loads on the ARSR-3 tower, tower-to-radome interface information and electromagnetic performance analysis.

(b) Fabrication specifications--covering acceptance procedure, quality assurance tests and packaging for shipment to erection sites.

(c) Erection drawings and specifications--including member/panel locations, fasterner sizes and methods, and other necessary instructions and data required for the correct field erection on top of 25' to 75' (in 12 $\frac{1}{2}$' increments) ARSR-3 towers with a minimum of personnel and equipment. A parts list showing part numbers and descriptions shall be provided as a part of the erection drawings. Instructions should include ground space requirements; sizes of erection equipment, such as, lifting equipment, and air compressors; method of attaching radome to tower deck; and estimated time of each erection operation. The specification shall contain complete provisions for testing and acceptance of the radome in-place. The specification shall include dismantling information.

(d) Instruction book--covering technical operating and maintenance information to be used by FAA maintenance personnel during the life of the facility (3.13.4).

3.2 General description.- The contractor shall design and provide a 65 ft. diameter rigid radome to protect the antenna at ARSR-3 facilities. The radome shall be of aluminum space frame construction composed of triangular panels. The design shall be such that the structural members are quasi-randomly oriented over the radome surface while simultaneously meeting the electromagnetic and structural environmental requirements specified herein. The radomes will be mounted on top of a steel antenna support tower. The radomes will be erected on sites selected by the FAA throughout the contiguous United States, including mountain top sites, and the erection contracts will be administered by the FAA. The radome should present an architecturally pleasing appearance since some will be located in proximity to residential areas. The radome shall be in accordance with all applicable requirements of Department of Labor Standard, Title 29, Chapter XVII, Part 1910.

3.3 Interface.- The radome being furnished under this specification is intended for use with a tower being designed under FAA-C-2498. The radome will shelter a radar antenna system specified in FAA-E-2483b. The contractor shall assure compatibility of the interface between components under his own design control and shall coordinate, through the Contracting Officer, to assure compatibility with components furnished by others.

3.4 Service conditions.- The radome shall be designed to sustain the maximum stresses imposed by the following ambient conditions without causing permanent deformation, crazing, cracking, or flow.

(a)	Temperature	-50°C to +60°C
(b)	Relative Humidity	5% to 100%, including condensation due to temperature changes
(c)	Wind Velocity	No less than 100 mph (not including gusts)
(d)	Live Load (including ice and snow)	30 psf
(e)	Seismic	Zone 3 of Uniform Building Code
(f)	Environment	½" diameter hailstones Salt spray and urban industrial fumes. Fungus as encountered in warm, humid atmospheres. Wind borne sand and dust as encountered in deserts and plains of Western U.S. Rain, rates up to 100 mm per hour and shall maintain its operational electromagnetic performance.

3.5 Radome

3.5.1 General.- The radome shall consist of reinforced plastic panels with integrally moulded structural flanges or a network of aluminum structural struts and ties covered by thin plastic panels which transfer loads only to the structural members. The former type is generally known as a load-bearing shell and the latter a space frame. The configuration of the radome shall be a faceted or smooth truncated sphere with a major horizontal diameter of 65 feet.

The radome base flange shall bolt to a radome mounting ring having 11/16" diameter bolt holes at 3° intervals on a 24'-10 7/8" +1/4" radius bolt circle. Caulking of joints shall not be used to obtain tight joints or to make level the flange contact area. Both shop and field joints shall be weatherproof and watertight. Panel joints shall present a smooth exterior to the complete radome. The configuration of each panel and the finished radome shall be such that no water will pocket on its surface.

If vents or equalizing ports are necessary to control internal radome temperatures, they shall be designed to be weatherproof and adjustable by maintenance personnel from a radiation safe location.

The radome shall be designed to facilitate fabrication, shipping, and erection. The largest size components shall be suitable for shipping in conventional commercial trucks or tractor-semitrailer combinations and handling by a 5 ton truck crane.

The radome shall be designed and constructed to have a nominal service life of at least 20 years.

Radome panels may be either bounded by the metal frame members or attached to the completed radome framework. The panels shall not be permanently fastened to the radome in a way preventing subsequent removal of individual panels or groups of panels.

3.5.2 Structural requirements.- The structural design shall be based on good engineering practice and incorporate the latest state-of-the-art technology for the materials used.

The design of plastic components shall use a minimum safety factor of 5 based on the ultimate tensile strength of the material and the resultant maximum stresses imposed on the radome from the load combinations specified herein. When the material selected for the radome flows or creeps under load and temperature change, allowance shall be made in the design by using values of the apparent modulus. To avoid crazing and/or cracks developing at areas of stress concentration and stress raising geometric details, the working stresses at these locations shall be reduced to a value appropriate for the material selected. The strength of all joints shall be equal to the base material. The temporary maximum deflection of the radome shall be such that the clearance around the rotating parts of the radar equipment shall never be less than 12 inches under the service conditions.

3.5.3 Material requirements.- The plastic portions of radome panels shall be constructed of fiberglass reinforced rigid plastic materials of the thermosetting of thermoplastic types.

The selection of all mechanical and electrical properties and combinations of materials to meet the requirements and intended use of the radome shall be accomplished by the contractor. All pertinent properties of the materials shall be detailed in design; and test methods for determining acceptability, such as ASTM tests and Federal Standards, shall be required in the fabrication specification.

The finished plastic panel material shall be judged "self-extinguishing" when tested in accordance with ASTM D-635, Flammability of Rigid Plastics over 0.127 cm (0.050 in.) in Thickness.

All metal structural members, hardware, and fasteners, for interior or exterior use, shall be corrosive resistant and be compatible with or isolated from material where possible galvanic action can be expected.

The exterior surface of plastic components shall have a factory applied protective coating of sufficient thickness to provide a service life of ten years, such as an integrally bonded film of Tedlar (Polyvinyl-flouride) or a coating of acrylic resin. The finish coating shall be weather and abrasive resistant, resistant to dirt pickup and retention, and formulated to resist degradation due to ultra-violet rays. The color of the coating shall be white. The interior plastic surfaces should be sealed or protected, as necessary, to not require recoating for the 20-year life of the radome. The exterior surfaces of all metal structural members shall be unpainted, corrosion resistant.

All adhesives shall be of the best commercial grade consistent with the physical, electrical, and operating requirements herein. Caulking compound shall be compatible with the contact surfaces and shall be high quality permanent type which is self-sealing and remains plastic for its useful life.

3.5.4 Electromagnetic requirements. - The ARSR-3 antenna radome shall not degrade the electromagnetic characteristics of the enclosed ARSR-3 radar and beacon antenna, as referenced to free space (no radome inplace) beyond the following limits. All pattern level limits are referenced to the peak of the main beam of the radar or beacon azimuth or elevation pattern as appropriate.

3.5.4.1 Antenna pattern distortion. - The ARSR-3 antenna radiation characteristics for free space are described in paragraph 3.9.4 through 3.9.14 of FAA-E-2483b. The beacon radiation characteristics are described in paragraphs 3.9.4.3, 3.9.5.3, 3.9.6.3, 3.9.7.1 of FAA-E-2483b, Supplement 3. The allowable pattern distortions due to the radome are as follows:

3.5.4.1.1 ARSR-3 radar antenna patterns. - Over the frequency band 1250-1350 MHz for both upper and lower beams on both vertical and horizontal polarization.

(a) Azimuth Patterns. Sidelobe levels in the principal plane (nose) shall not increase more than 1.5 dB. Sidelobe levels, in cuts not in the principal plane, and back radiation levels shall not increase more than 2.5 dB.

(b) Elevation Patterns. The level of the sidelobes on the underside of the beam shall not increase more than 1.5 dB.

3.5.4.1.2 Beacon Directional Antenna patterns. - Over the frequency band 1030-1090 MHz with vertical polarization.

(a) Azimuth Patterns. Sidelobe levels in the principal plane (nose) shall not increase more than 1.5 dB. Sidelobe levels, in cuts not in the principal plane, and back radiation levels shall not increase more than 2.5 dB.

(b) Elevation Patterns. - The level of the side lobes on the underside of the beam shall not increase more than 1.5 dB.

Note: Pattern levels are referenced to the peak of the main beam in both cases.

3.5.4.1.3 Beacon Omni-directional antenna pattern. - At 1030 MHz the azimuth radiation pattern shall be omni-directional within 1.5 dB; the elevation pattern shall match the directional elevation pattern to within ±3 dB from -5 degrees to +35 degrees.

3.5.4.2 Transmission efficiency. - Quantitative assessment of the composite gain of the ARSR-3 antenna, beacon antenna and the ARSR-3 antenna radome integrated as a system shall be as follows.

3.5.4.2.1 ARSR-3 radar antenna pattern. - Over the passband 1250-1350 MHz on both horizontal and vertical polarization loss with radome shall not exceed 0.6 dB one way. Transmission gain has no limit.

3.5.4.2.2 Beacon directional antenna pattern. - Over the passband 1030-1090 MHz with vertical polarization, transmission loss with radome shall not exceed 0.6 dB one way. Transmission gain has no limit.

3.5.4.2.3. Beacon Omni-directional antenna pattern. - At 1030 MHz with both vertical and horizontal polarization the transmission loss shall not exceed 0.6 dB one way. Transmission gain has no limit.

3.5.4.3 ARSR-3 beam deflection. - The beam deflection due to the antenna radome shall not exceed 0.01° over the frequency range.

3.5.4.4 ARSR-3 radar Beamwidth. - Over the passband 1250-1350 MHz of both upper and lower beams on both horizontal and vertical polarization changes in beamwidth due to radome shall be plus no limit, minus zero.

3.5.4.5 RF power reflection. - Over the passband 1250-1350 MHz changes in VSWR due to radome shall not exceed ±2.5%.

3.5.4.6 Depolarization. - Over the passband 1250-1350 MHz for the ARSR-3 radar antenna with radome the degradation of the cross-polarization component and the integrated cancellation ratio (ICR) shall not exceed 1.0 dB.

3.5.5 Interchangeability. - All radomes or parts of the radome having the same part number shall be directly and completely interchangeable with each other with respect to installation and performance. Part numbers shall be stamped into the radome parts at the factory for permanent identification.

3.5.6 Maintainability. - The individual radome panel membranes shall be capable of being repaired in-place, as directed by the Instruction Book, when penetrated by wind borne debris. The time to replace a single panel anywhere in the radome, using equipment described in the Instruction Book shall not exceed one hour, exclusive or scaffolding time required. The radome shall be self-supporting and not require shoring when any group of panels covering a 12' x 18' area is removed under maximum wind conditions of 25 knots. The requirement is not subject to test but shall be validated by calculations. The protective coating of the exterior radome surface shall be compatible with future field

recoatings. Field recoating of the exterior radome surface shall not require more than 24 hours of radar down time utilizing a 3 man crew (3 each 8 hour daylight periods).

3.6 Data plate. - A plastic data plate, approximately 3" by 6", shall be bonded to the inside surface of each radome 12" above the base flange. The plate shall have the following information permanently engraved or embossed into the surface:

RADOME, 65 FT. RIGID, AIR ROUTE SURVEILLANCE RADAR
Manufactured by (manufacturer's name) for
FEDERAL AVIATION ADMINISTRATION
Contract No. _____
Serial No. _____
Radome Subcontractor: (if applicable)

The manufacturer's name shall not be visible on the finished radome except on the data plate.

3.7 Access hatch. - Two personnel hatches shall be provided on opposite sides of the radome for access to the tower walkway outside of the radome. The minimum size hatch shall be approximately 5 1/2" high by 3' wide, and shall have latch handles on the inside and outside. The hatch shall be hinged outward and provision shall be made for securing it in the open position. When closed it shall be weathertight and waterproof.

3.8 Lightning protection. - The radome shall have a lightning protection system in accordance with the Lightning Protection Code, NFPA Publication No. 78. The radome shall be integrated with the tower lightning grounding system. The system shall not degrade the ARSR-3 equipment performance. The grounding circuits shall be capable of dissipating direct hits without damage to the radome. The grounding circuits shall be supported close to the exterior surface of the radome. Lightning air terminal openings through the radome shall be weathertight and waterproof.

3.8.1 Aircraft Obstruction Lights (Option). - When required by the Government a two-lamp aircraft obstruction light assembly shall be supplied and mounted, integral with the lightning rod and service rope assemblies at the radome zenith. Obstruction light assembly shall be in accordance with AC 70/7460-1C. Burnout of obstruction lamps should be readily noticed by visual inspection from ground.

3.9 Outside service ladder.- An outside service ladder of magnesium or aluminum shall be of the hinged section type, sized to follow the contour of the radome. The assembled ladder shall extend from its attachment point at the lightning rod assembly to a point above the tower deck such that it can be climbed directly from the tower deck. Each ladder section shall be supported on soft rubber swivel casters sized to prevent damage to the radome surface and protective coating. A minimum 3" clearance shall be maintained between the ladder side rails and the radome. The ladder shall fold up and fit into a storage case. The ladder shall be designed for easy erection by one man.

3.10 Ring and pulley assembly.- An interior hoist ring and exterior horizontally mounted pulley shall be permanent integral parts of the lightning rod assembly at the apex of the radome. The pulley shall be used to raise the outside service ladder. The interior ring will be used with block and tackle to handle materials. Each ring and pulley shall be capable of individually supporting 500 pounds (not simultaneously).

3.11 Exterior rope.- A stranded nylon rope of interwoven construction, approximately 5/8" diameter, shall be provided to raise and lower the service ladder and serve as a snow rope. The nylon shall have an ultra-violet absorber and have bright yellow dye dispersed throughout the material.

3.12 Base attachment hardware.- All hardware, gaskets and weather seals required to attach the radome to the mounting ring shall be provided by the radome manufacturer. The joint between the radome and the mounting ring shall be weatherproof and watertight.

3.13 Documentation.

3.13.1 Drawings and technical memoranda.- The contractor shall be responsible for maintaining an up-to-date record of all internal drawings and technical documents produced or used in the design, fabrication, and testing of the ARSR-3 antenna radome and those documents furnished the Government. The contractor shall provide the Government an index of all items. The index shall be initiated on award of the contract and shall be updated monthly submitted with the monthly progress report. All engineering drawings submitted by the contractor shall meet requirements of FAA-STD-002. All lined pencil work and lettering shall be of high quality such that it can be clearly interpreted on all types of reproduction processing. Original drawings are to be prepared in Herculean, Cronaflex, or Kodax mylars with mylar pencil. Drawing are to be standard FAA "D" size with the FAA title block (refer to FAA-STD-002, Amendment 1, Figure 2a, dated 10/6/67).

3.13.2 Microfilm copies.- Within 90 days following final Government acceptance of the first ARSR-3 antenna radome, the contractor shall furnish two complete microfilm copies of all drawings and documentation prepared for or used on the contract. The microfilm reproduction shall include all information supplied by the vendors in connection with subcontract materials.

The microfilm shall be 35 mm mounted on a standard FAA aperture card. Each card shall be labeled with the FAA contract number, equipment designation (ARSR-3), prime equipment manufacturer's name, and drawing or document number. If revisions to the drawings and documentation are made after the original photographing and before contract completion, replacement microfilm for the revised drawings and documentation shall be furnished within 60 days of the effective revision date. The first microfilm copies submitted shall be based on the ARSR-3 configuration at the time of successful completion of factory test specified in paragraph 4.3 of FAA-E-2483b.

3.13.3 Specifications.- Specifications for the designs shall be prepared in accordance with FAA-STD-005b. The drawings and specifications developed shall be complete to the degree that they can be subsequently used by the Government without modification as technical documents for inclusion in a Government contract for fabrication and erection.

3.13.4 Instruction book.- The instruction book shall be prepared in accordance with Specifications FAA-D-2494, Parts 1 and 2.

3.14 Design submission and approval.- The contractor shall furnish the Contracting Officer three copies of all drawings, specifications, and calculations in the following order. Submission times are as shown in the contract schedule.

(a) Erection drawings and specifications (3.1.2b) and (3.1.2C)

(b) Instruction Book (3.1.2d)

No fabrication work shall be started until submission (a) has been approved by the Contracting Officer. Approval or required changes for the initial submission will be transmitted to the contractor by the Contracting Officer within forty-five (45) days after receipt by the Government. Subsequent resubmissions will be returned within twenty-one (21) days. Design approvals shall in no way relieve the contractor from meeting the requirements of this specification.

3.15 Antenna Radome Qualification Testing.- Special antenna radome electromagnetic design qualification tests are required at the first site designated by the Government. These tests shall be conducted in accordance with paragraph 4.3.4 and subsidiary paragraphs.

4. QUALITY ASSURANCE PROVISIONS

4.1 Quality control.- The contractor shall provide maintain a quality control program in accordance with FAA-STD-013a. All tests and inspection shall be subject to Government inspection.

4.2 Documentation.- The contractor or his authorized representative shall sign the original tracings of all drawings and the first page of all specifications, estimates, or similar documents under the contractor's printed name and over the affixed replica of his professional seal or his registration certification number including the state or jurisdiction of issue.

4.3 Radome

4.3.1 Erection test.- The first radome produced shall be erected by the contractor using erection drawings, equipment, and methods required in the erection specification. Dimensional measurements shall be made to determine if they are within the specification and design requirements. The fit of individual panels shall be checked for proper fit and leaks after bolts are properly torqued. Ease of assembly shall be checked with particular attention to adequacy of erection marks and ease of bolting. The erection test shall include a demonstration of the ease of removal and replacement of individual panels. The erection shall be made at a location approved by the Contracting Officer with all site preparation and the base ring provided by the contractor. Revised copies of all documentation shall be furnished to the Government, as necessary, after completion of the assembly test.

4.3.2 Quality control panel.- At the beginning of production the Contracting Officer's Representative shall select a representative panel, fabricated in accordance with the process specification, to be preserved as a visual quality standard for the remainder of the contract. This panel shall represent the minimum acceptable quality of workmanship and shall serve as the standard for visual comparison with subsequent panels.

4.3.3 Production tests.- The production run of radomes shall be tested in accordance with the specification provided in paragraph 3.1.2(b).

4.3.4 Electromagnetic tests.- Electromagnetic tests as set forth herein are to be considered as part of the electromagnetic design qualification test and shall be in accordance with FAA-G-2100. If the contractor's manufacturing process is such that he can demonstrate reliable and consistent production to the approval of the Contracting Officer, no further electromagnetic tests will be required. If batch production is changed, qualification tests or suitable alternate procedures for verification of electromagnetic requirements shall be performed as required by the Contracting Officer. Alternate procedures shall be submitted to the Government in accordance with FAA-G-2100, and FAA-STD-013a for approval.

4.3.4.1 Equipment and services to be furnished by the contractor.- The contractor shall provide the test instrumentation and services which are acceptable to the Government; that are required to perform the tests specified herein. Records of tests, including examination and inspections, shall be kept complete and available to the Government. The Government reserves the right to witness or participate in any of the tests set forth in this specification.

This series of tests shall be conducted at the first designated site listed in the contract schedule and prior to the on-site acceptance tests required in paragraph 3.8.9.4.2, FAA-E-2496b. The purpose of the test is to ascertain whether the radome has any measurable effect on the radar and beacon antenna patterns with respect to transmission efficiency, antenna pattern distortion or beam deflection. The test results of the radar and beacon antenna pattern tests taken during the design qualification tests (paragraph 4.3.3, FAA-E-2483b) shall be used as a standard together with design calculations and other tests conducted on the ARSR-3 antenna radome. Antenna patterns shall be taken with an instrumented FAA aircraft with and without the ARSR-3 antenna radome in place. The FAA aircraft shall fly a prescribed series of radial and orbital flights and the antenna transmit and receive patterns shall be recorded and the test results evaluated. These tests as a minimum, shall consist of the following:

(a) Antenna pattern distortion

(b) Transmission efficiency

(c) Beam deflection

The above tests cover the principal electromagnetic design qualification tests for the antenna radome. Design calculation, prior antenna modeling test results, or other suitable tests may be used to validate the remaining electromagnetic requirements upon approval by the Technical Officer (T.O.).

4.3.4.2 Equipment and services to be furnished by the Government.- The Government will provide a suitable piloted test aircraft. (The contractor shall request the aircraft in writing to the T.O. 30 days prior to the scheduled test. The contractor shall provide suitable instrumentation for recording antenna patterns.)

4.3.4.3 Procedures.- Submission and approval of test procedures shall be as specified in FAA-STD-013a. When approved, the test procedures shall apply whenever radome electromagnetic tests are specified herein.

4.3.4.4 Electromagnetic design qualification test.- Tests specified in FAA-G-2100 shall be performed on the first radome at the first designated site. The transmit antenna patterns shall be measured in an environment that approximates a free space pattern (radar antenna at the maximum available tilt). The receive pattern shall be measured by using a stable airborne signal source radiating through the same aircraft antenna used to receive ARSR-3 transmit patterns and recording results with the ARSR-3 receiver. Appropriate test flights (orbital and radial) the radar antenna not rotating and rotating, shall be made. Suitable alternate procedures may be substituted upon approval by the Technical Officer (T.O.).

5. PREPARATION FOR DELIVERY

5.1 Equipment.- The contractor shall be solely responsible for protecting, preserving, packing, and marking all equipment for delivery to field installation sites. The equipment shall arrive at the sites in full accordance with the requirements of this specification and acceptable for erection by the contractor or others.

5.2 Documentation.- The contractor shall be responsible for packaging, marking and shipping all documents required by this specification to the locations specified by the Contracting Officer.

6. NOTES

None

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